

Method of integrating an application in a computerized system

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## TECHNICAL FIELD

The present invention is concerned with a computerized system for control. In particular the present invention is a method for integrating many and varied types of applications within the 10 computerized system, and the computerized system employing the method. The method and the system may be used for controlling a number of single devices, an object in a process, a complete equipment, in any location including a home, as well as a process or an industrial installation such as a steel mill, a 15 paper mill, and an automated factory.

## BACKGROUND ART

In contemporary computer based systems for controlling manufacturing and process industries, such as chemical plants, 20 oil refineries, pulp and paper mills, steel mills, etc., there has typically existed a large range of different applications of different origin that have had to be integrated into a single control system. Further, a control system typically includes several computers connected through a communication network, 25 where said applications are distributed in different configurations for different installations. Traditional methods for this integration have entailed extremely lengthy development times resulting, for example, in significant changes in requirements before such control programs have been completed 30 and made ready for use. A second problem with traditional development methods is that it has been difficult and lengthy to update such control programs to include new requirements, such as the integration of additional and new applications. Writing and modifying control system programs to combine newer 35 applications with older, existing applications, which older

applications are sometimes called legacy applications, has also been difficult, time consuming and expensive.

The adoption of object-oriented programming languages and 5 methods has led to somewhat shorter development times, and made it somewhat easier to incorporate or integrate new applications.

IEC standard DIS ISO/IEC 1346-1 1995 Structuring principles and reference designations, contains a reference designation system 10 for the unambiguous identification of parts of any system in the general technical context such as in a manufacturing company, plant or operating company. Within this description the terms object, aspect and reference designations in particular are used to refer such parts of any system in the general technical 15 context in accordance with the definitions in DIS ISO/IEC 1346-1. In addition, certain additional types of objects and aspects will be additionally defined in the course of this description.

US 5 787 425 describes a concept of client/server relationships 20 between objects in an object-oriented computer program. Objects communicate with each other, for example in order for a first object to access data held by a second object. When the first object needs access to some data controlled by the second object, the first object is considered to be a client of the 25 second object, which in turn is considered to be a server. To access the data controlled by the server object, the second object in this example, one of the operations of the first object, the client object, will call or invoke one of the operations of the server object. The operation of the server 30 object thus invoked is then executed to access and/or manipulate the data on behalf of the client object.

When the client object and server object both exist and run in the same process (memory space) in the same computer, the server

object is described as being "in process". When the client and server objects run in different processes (memory spaces) in the same computer, the server object is described as being "local". When the client and server objects run in separate computers, 5 the server object is described as being "remote".

The standard operation of an Object Request Broker (ORB) is to handle requests between client and server objects. The ORB makes the handling of requests transparent to the client object 10 whether the server object is in process, local or remote.

A known example of an ORB is published by Microsoft and is called Component Object Model (COM). It is a standard for interoperability between software components introduced in 1993. 15 COM is independent of programming language and supported by many widely used computer operating systems such as Windows, Mac OS, and many types of Unix. It uses a single model for software components to communicate with each other, both inside the same computing process and also across process and network 20 boundaries. COM is also associated with ActiveX (Trademark), a system of software controls that use COM technologies. The COM standard of 1995 is described in The Component Object Model Specification available in the Microsoft MSDN Online Library on the web site maintained by Microsoft. Additional information 25 about COM may be found in, amongst others, an article in Dr. Dobbs Journal December 1994 entitled The Component Object Model: Technical Overview.

A publication called COMponents by Steve Robinson and Alex 30 Krassel of Panther Software (address) discusses the use of COM objects in object-oriented programming. The article discusses how to use object-oriented programming with known techniques. It presents an example of how a method of a first software object may be invoked by an application running in the same computer

system by means of a COM compliant interface in the first software object. The method depends on the application having prior information about the first software object, information such as a CLSID, in order to establish a reference (such as a 5 pointer) to the interface.

In a patent WO 97/22925, entitled "A method and system for constructing software components and as assemblies of independent parts", a method is described for the purpose of 10 improved engineering of software, which means in other words writing software programs, in order to achieve faster performance and lower demand on system overheads. The description of the method includes a terminal interface and a terminal mechanism for interfacing (software) objects. The 15 method also requires further information, a second data connection set, before it may be determined whether a method invokable by a first (software) object through a second (software) object, such as a new object, can participate in a connection and thus provide a method to or from the second (new) 20 software object.

The adoption of object oriented programming and client-server approach has provided design tools that make it easier to design computerized systems with re-useable modules that co-operate in 25 a standardized way to perform the collective functions of the system. However, it is necessary to integrate applications of different origin, that are implemented using different object and non-object technologies, including new applications, as well as applications that were anticipated but not known in detail at 30 the time of planning a computerized system. Conventional system design requires that an object in a computerized system has prior information about an application in order for the object to, for example, access a method implemented by the application. A new way to design systems is required to integrate

applications, such that different applications can be both fully independent, based on different technologies, and without knowledge of the specifics of each other, and at the same time able to co-operate with each other to perform the collective 5 functionality of the computerized system.

#### SUMMARY OF THE INVENTION

An object of the invention is to provide a method to integrate an application in a system for computerized control of a real 10 world object, and a system in which the method is employed. Another object of the invention is a method to integrate an application such that prior information about the application need not be specified. Another object of the invention is to provide a method to represent real world objects in a 15 computerized system in a systematic way, in which different types of information about the real world object may be obtained, linked to the real world object, processed, displayed and acted on, and a system employing same. Another object of the invention is the integration of a large range of applications 20 within the system in a modular manner. Another object of the invention is to provide a method for the integration of later and additional applications into an existing system. Another object of the invention is to provide for the integration of different applications that are implemented using different 25 object and non-object oriented technologies. Another object of the invention is to provide a system and method in which separate applications that are independent and without knowledge about the specifics of each other, are able to co-operate to jointly provide system functionality that is associated with 30 said real world objects. A further object of the invention is to provide a method and system in which control of equipment may be achieved in any location including a home or residence. These and other objects are achieved according to the present invention by a method as described in claim 1 and a system as

described in claim 14, and a computer program product described in claim 28. The present invention may be described summarily as a method for designing a computerized system, and a system employing same method, in which one or more real world objects

5 are represented by an object called a Composite Object. The Composite Object is a part of a computer program included in the computerized system. One or more facets of the real world object, such as a physical location, a stage in a process, a control function, an operator interaction, a simulation model,

10 some documentation about the object, etc are described as one or more Aspects of the Composite Object. A central feature of the present invention is that each Composite Object is a container for one or more Aspects of the real world object which represent the real world object.

15 An important new and useful element of the present invention lies in that different applications may be used to implement different Aspects or groups of Aspects of a Composite Object. Each application defines interfaces that are independent of the

20 implementation of the application itself. These interfaces may be used by other applications, implementing other Aspects or groups of Aspects of the Composite Object, such that the applications can co-operate to provide a functionality that is the sum of all Aspects, i.e. the functionality of the Composite

25 Object. The interfaces are specified as COM interfaces, where COM interfaces are implemented by COM objects as described above. The interfaces may be in-process, local, or remote. Internally, each application may use any object oriented technology, such as C++ or Java, or non-object oriented

30 technology such as relational databases, sequential files, etc..

Many different types of application may be used to implement Aspects. For example a word processing program may be used by one Aspect to display a functional specification, and by another

Aspect to edit operator notes. Similarly a CAD program may be used by an Aspect to display a drawing, and used by another Aspect to display an electrical diagram or by a third Aspect to display a piping and instrumentation diagram. Application 5 programs are not limited in any way to those programs used in traditional process control methods. For example a production management application may be used by one Aspect to display a job order, by another Aspect to run an equipment schedule or by a third Aspect to show material in stock.

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The principal advantage of the present invention is that a large range of applications may be integrated into a computerized system in a modular and independent fashion. Each application is, by means of Composite Objects and Aspects contained by 15 Composite Objects, responsible for its own data and operations. This means that applications that are internally based on different object or non-object oriented implementation technologies can be integrated in such a way that no difference is apparent between the methods for supplying services provided 20 by the different applications. This also means that modifying an application or adding an application requires no change to other applications in the system. This is a particularly useful feature of the present invention because it facilitates the addition of new Composite Object types which may require 25 addition of new Aspects, including new applications to manage these new Aspects. Another advantage of the invention is that Aspects of a Composite Object provide a method to indicate inheritance which enables Composite Objects to inherit certain Aspects automatically without necessarily defining inheritance 30 relationships between specific Composite Objects.

The present invention thus provides important benefits in several respects including: i) for the developer of a system, who can integrate existing, new, and future possibly not yet

anticipated applications, without having to significantly rewrite every application to fit with any particular data model or implementation technology, ii) for the user of the system, who will perceive a seamless integration of vastly different

5 applications that co-operate to provide the full functionality that is associated with the real-world entities that he or she is dealing with and iii) for the owner of the system whose investment is protected because the system may be developed with, or extended by, applications not previously anticipated.

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The applicability of the present invention is not limited to traditional process control functions and use, but extends as well to many other areas. This includes business and commercial activities such as production management, design and maintenance

15 systems, and business and financial systems. It also includes control of equipment in other locations including equipment or processes in a residence or a home.

#### BRIEF DESCRIPTION OF THE DRAWINGS

20 The present invention will be described in more detail in connection with the enclosed drawings.

Figure 1 shows schematically a COM Object with interfaces according to a known standard, COM.

25 Figure 2a shows schematically a Composite Object and Aspects according to an embodiment of the present invention.

Figure 2b shows schematically an Aspect Type of an Aspect according to an embodiment of the present invention.

Figure 3 shows schematically the handling of a query by a

30 Composite Object through an Aspect Type according to an embodiment of the present invention.

Figure 4 shows schematically a scheme of inheritance for Aspects of a Composite Object according to another embodiment of the present invention.

Figure 5 shows schematically inheritance for Aspects of a Composite Object in the same Structure according to a preferred embodiment of the present invention.

5 DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1 shows a COM object 5 with three known interfaces 1, 2, 3, and a standard interface 4, which interface is known within the COM model as IUnknown. COM is an existing standard.

10 In order to facilitate understanding of the invention, it is necessary to explain some details of about COM. Development of computerized systems using COM aims at developing one or more COM objects. The COM object provides its services via methods, which are grouped into one or more interfaces. Each interface, 15 such as interfaces 1- 3 of Figure 1, typically includes methods that supply a specific range of services. Through these interfaces, a client object can invoke the methods defined by the COM object. The set of interfaces that are supported by a specific COM object may change as the object undergoes revisions 20 and updates, but any interface once defined always stays the same. In this way problems with versions and backwards compatibility are minimized. All COM objects support an interface which is named IUnknown. This interface controls the life time of the object (through reference counting) and allows 25 client objects to obtain information about other interfaces supported by the object. The convention of IUnknown thus allows COM objects to interact without each object previously having information about every possible interface that may be supported by every other object. Figure 1 illustrates a COM object 5 with 30 several interfaces, which interfaces always include an instance of IUnknown. A client object can query a standard COM object 5 for an interface, but in order to do that, the client object has to know the identity of the object (or application) for which it is seeking an interface. If the object supports the interface

then a reference to the interface is returned as some form of pointer to where that interface may be found.

COM is a published standard and as such is a part of the prior art.

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In a method to integrate an application in a computerized system for control of a real world object and a system using same method according to an embodiment of the present invention, a Composite Object represents any real world object. The real 10 world object may be an actual object such as a pump, a motor, a valve, etc., or a more abstract object such as a purchase order, production batch, etc. The present invention is not limited to traditional control or process control areas. Any real world object may be represented, as an object in a process, including 15 a device or process in a home for example, or a person carrying out a stage or role in a process, or intangible objects such as messages, a location, status of information etc..

Referring to Figure 2a, which shows a first software object, 20 called a Composite Object 40 containing some Aspects 41. The Composite Object 40 is a container, holding different Aspects1, 2, 19, 23 etc. related to the real world object. An Aspect represents one facet of the real world object, and is responsible for all operations on that facet of the object and 25 its data. Thus for a pump for example, one Aspect could represent a physical location, another Aspect could represent a blue print diagram of the pump, another represents a security descriptor for the pump, another Aspect represents a control for an operation of the pump and yet another Aspect represents 30 documentation about the pump. The Aspect that represents the facet has an association to a function of an application that can, referring to the above example, display the blue-print diagram, or control the operation of the pump.

Composite Objects and Aspects communicate with each other using a "framework" based on an Object Request Broker such as COM with additions defined according to the present invention. A set of interfaces are defined to allow Aspects to co-operate using 5 standard services. Any individual Aspect may define additional interfaces, to allow for any specific interaction that may be required within a subgroup of Aspects.

In an embodiment of the present invention, each of the real 10 world objects represented in the system is represented within a computer program as a Composite Object. In order to do this the computer program contains software code means to direct a computer to carry out functions according to an embodiment of the present invention. The Composite Object contains one or more 15 Aspects representing facets of the real world object that the Composite Object represents. These Aspects also have associations to applications that provide functionality that is associated with the respective facets of the real-world object.

All Aspects are created through an Aspect Category. The Aspect 20 Category contains information that is shared between all instances of the category. Each Aspect Category refers to one Aspect Type. This Aspect Type describes the implementation of an Aspect.

An Aspect belongs to an Aspect Type (through its category) which 25 lists the set of COM objects that implements the functionality of the aspect. This implementation is provided by an object, referred to as an Aspect System Object (ASO), which is a COM compliant object. The Aspect System Object is a second software object which has a specific function, to implement certain 30 Aspects as described below, that is different to the function of the first software object, the Composite Object, the function of which is to represent a real world object by acting as a container for Aspects. Stated differently, the Aspect Type

contains the binding information between an Aspect and the one or more applications that implement its functionality.

The Composite Object may be queried by a client, through an Object Request Broker such as COM, to find a reference for an 5 interface of the application associated with any of its Aspects.

An Object Request Broker such as COM provides a mechanism to communicate a reference for a particular interface. The "framework" provided by Composite Objects and Aspects provides the means to identify the particular interface that the Object 10 Request Broker subsequently communicates.

See Figures 2b and 3. Figure 2b shows a Composite Object 6, an Aspect Category 19a that Aspect 6a belongs to, and an Aspect Type 8 for the Aspect 6a according to an embodiment of the invention. The Aspect Type 8 contains a listing of all Aspect 15 System Objects used by this Aspect, expressed as a class identifier 9 (CLSID) of each ASO and a list of all interface identifiers 7 (IID) for interfaces supported by each ASO. A CLSID, such as CLSID 9, identifies a particular application, and, by this means, associates a function of the Aspect with the 20 application that implements the function.

Figure 3 shows a Composite Object 10, which includes an interface IUnknown 4a. Also shown is an Aspect System Object 101, which includes another interface IUnknown 4b. Figure 3 also shows a query 13 for an interface and a reference 103 to an 25 interface 102. From Figure 3 it is seen that when a client queries the Composite Object 10 for an interface, the reference 103 that is returned comes from the Aspect System Object 101. The ASO 101 is found through a table look-up using the Aspect Type, as shown in Figure 2b.

30 The result of this is that the client querying, for example, Composite Object 10, for a function associated with one of the

Aspects of Composite Object 10, does not need to know the identity of the object (or application) for which the interface is being sought, the client simply queries the Composite Object for the function associated with the Aspect. This is in contrast 5 to the standard use of COM, which requires that a client object explicitly knows the identity of the object (or application) for which it is seeking an interface.

A Composite Object is uniquely identified through its object identifier. An Aspect is identified by the object identifier of 10 the Composite Object it is associated with, and a unique aspect identifier. If an object has a representation in different systems it uses the same object identifier in all systems.

**Finding an interface through a Composite Object according to the invention.**

15 A client of a Composite Object queries the object for an interface. The Composite Object uses the definitions contained by the Aspect Type of the Aspects of the Composite Object to identify the Aspect System Object that implements the requested interface. This ASO is then created and initialized from the 20 Aspect it represents, or, if it is already running, found through a mechanism of locating running objects. A reference to an interface of this ASO is then returned to the client.

Whenever a client interacts with a Composite Object a COM object is instantiated which represents the Composite Object.

25 See Figure 2b. The mechanism for finding the Aspect System Object which implements an interface of an Aspect is described thus. When a client queries a Composite Object 6 for an interface, the Composite Object examines its Aspects, including Aspect 6a, through the Aspect Category 19a, for an Aspect Type 8 30 which lists an ASO Description 8a that contains an interface identifier 7 of the requested interface. From the same ASO

Description 8a the class identifier 9 of the Aspect System Object which implements the interface is obtained.

See Figure 3 which illustrates a request to a Composite Object for an interface. Figure 3 shows a Composite Object 10 which 5 receives query 13 from a client. The Aspect Type 8 is searched, as shown in Figure 2b, to find the Aspect System Object class identifier 9. The Aspect System Object 101, if not already running, is created as indicated by process 14 Initialization in Figure 3. The instantiated Aspect System Object 101 is then 10 queried through the interface IUnknown 4b for a reference to the interface 102, which reference 103 is returned to the client.

Aspect System Objects can be defined to be shared or exclusive. This specifies if a client requests an interface several times for the same Aspect, it will get the same interface reference to 15 the object several times. If an Aspect System Object is shared then only one interface reference with a specific aspect identifier is created in each context (typically per process).

#### **Adding objects and functions according to the invention**

The above described mechanism makes it possible to extend the 20 functionality of the control systems by adding Aspects to Composite Objects, where each Aspect brings one piece of functionality. It also allows the implementation of the computerized system to be modularized, because each Aspect is 25 independent from all other Aspects except through the interfaces it supports and utilizes.

In a system that is implemented based on the principles of this invention, a developer adds functionality by adding aspect systems. An aspect system is an application that implements one or more Aspects, thus allowing Aspects instances to be created 30 and added to Composite Objects. The aspect system defines (among

other things) which COM objects are used to implement the Aspects.

It is also possible to add functionality to an existing aspect system by adding new ASOs to the Aspect type.

##### 5 Preferred Embodiment

In a preferred embodiment of the present invention, a method to organize Composite Objects after one or more real-world relationships is included, which method is called Structures. Any Composite Object in a system can be arranged in one or more 10 Structures.

For example a number of Composite Objects representing parts of one physical system may be conveniently grouped as a Structure. Composite Objects representing a sensor attached to a blade of a stirring device, the shaft of the stirring device, a temperature 15 sensor in the stirring device and a control unit for the stirrer, etc., may all additionally be identified as belonging to a particular Agitator Structure.

The Structure itself is represented as an entity that is separate from the included Composite Objects. Each node in a 20 Structure is represented by a structure Aspect of the Composite Object that is "placed" in that node.

The use of Structures means that relations between Composite Objects are represented by Aspects of the Composite Objects. This allows a Composite Object to be represented in multiple 25 Structures and even in multiple positions within one particular Structure. Structures allow Composite Objects to be organized and allows functions such as inheritance, sorting and grouping to be naturally defined.

A first object can inherit through a known mechanism of general 30 inheritance by being defined as a child of a second object. The

child (first object) then inherits those aspects from its parent object (second object) that are marked as to-be-inherited.

The present invention defines an additional and new method of inheritance. Aspects refer to Aspect Categories, and through 5 categories to Aspect Types. Aspect systems, Aspect Types and Aspect Categories are all represented as Composite Objects. By placing additional Aspects in an Aspect Category and marking these Aspects as to-be-inherited, these aspects are inherited to all Composite Objects to which any Aspect of that particular 10 Aspect Category is added.

This form of inheritance is illustrated summarily in Figure 4. A Composite Object 18 is a container for some Aspects, including Aspect1. Aspect1 refers to an Aspect Category 19. In the Aspect Category 19 Aspect2 and Aspect4 are marked as to-be-inherited. 15 Because Composite Object 18 contains at least one Aspect from Aspect Category 19, which in this example is Aspect1, Composite Object 18 will inherit all Aspects in Category 19 that are marked as to-be-inherited. The Composite Object 18 thus inherits Aspect2 and Aspect4 automatically by means of the to-be-inherited indicator on those Aspects in the Aspect Category 19. 20 The mechanism described above works recursively. The present invention also defines another new method of inheritance, shown schematically in Figure 5. A Structure 20 includes a first Composite Object 25 and two other Composite Objects 26, 27 that 25 are organized in the same Structure. Composite Objects 26, 27 automatically inherit Aspect32 from Composite Object 25 because Aspect32 is marked as to-be-inherited by Composite Objects when organized subordinated in the same Structure. This method of organization within a Structure may be based on any 30 relationship, typically one that reflects a real world function, and is not limited to descriptions such as a class in a hierarchy. The marker for "to-be-inherited-within-the-same-

Structure" is placed in the Aspect Category of the respective Aspects.

A system employing a method according to the present invention may also take the form of a distributed system because it is  
5 designed using methods that facilitate communication between, and execution of, applications running on computers in a distributed system. Distributed system here means a system that is spread over a plurality of computers, computer systems, computer networks, intelligent and non-intelligent devices that  
10 are arranged with communication devices so that each part of the system may communicate with any other part.

It is within the scope of the claims of the present invention to include computerized systems that comprise any communication means or combination thereof, including but not limited to  
15 direct hard-wired links, networks, intranets, the Internet, public or private telephone lines, radio links, infra-red links or links using optic fibers.